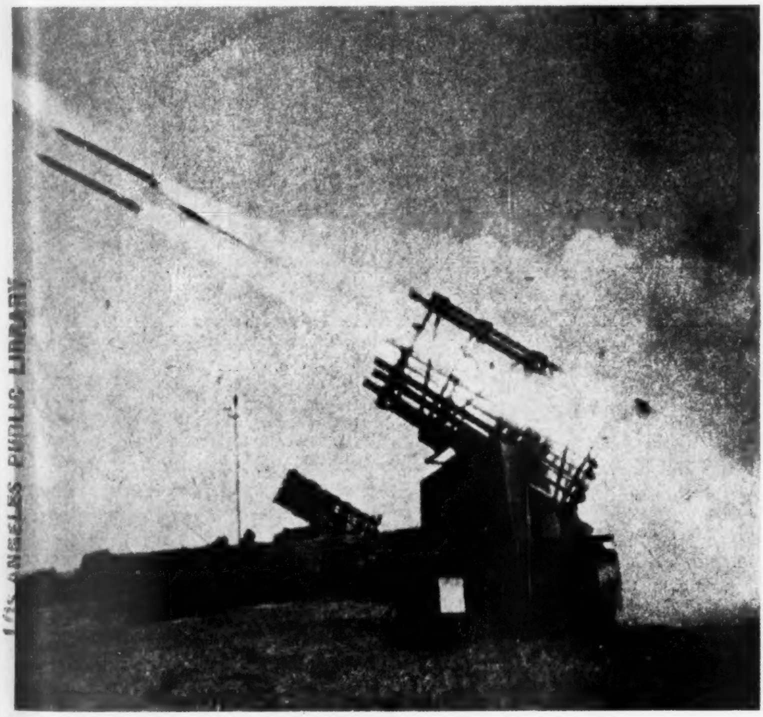
ASTRONAUTICS

Journal of the American Rocket Society

Number 58 June, 1944



LOS ANGELES PUBLIC LIBRARY

BRITISH "Z-GUNS" — Rocket leaves multi-barreled mobile weapon when small charge is electrically ignited. A linen patch is first blown out then expanding gases of the two second slow-burning powder charge propel the rocket upward. Momentum carries the ack-ack projectiles to four mile ranges.

THE AMERICAN ROCKET SOCIETY

was founded to aid in the scientific and engineering development of jet propulsion and its application to communication and transportation. Three types of membership are offered: **Active,** for experimenters and others with suitable training; **Associate,** for those wishing to aid in research and publication of results, and **Junior,** for High School Students and others under 18. For information regarding membership, write to the Secretary, American Rocket Society, 130 West 42nd Street, New York City.

OFFICERS OF THE SOCIETY

President - Cedric Giles
Vice-President—Constantin P. Lent
Treasurer—Samuel Lichtenstein
Secretary—James Wyld
Editor of Astronautics—Roy Healy
Chairman of Board of Directors—
G. Edward Pendray

ADVISORY BOARD

James R. Glazebrook, Chairman
Dr. H. H. Sheldon, American Institute of the City of New York
Dr. Alexander Klemin, Daniel Guggenheim School of Aeronautics
Dr. George V. Slottman, Air Reduction Company
I. I. Sikorsky, Vought-Sikorsky Aircraft Co.
J. O. Chesley, Aluminum Co. of America

NOTES AND NEWS

One of the most active amateur groups experimenting with dry fueled rockets in the United States is the Glendale Rocket Society, 3262 Castera Ave., Glendale 8, California. Founded in January 1943, under the name of the Southern California Rocket Society, the organization conducted a number of powder rocket model flights. On March 17th, 1943 the society was reorganized under its present name, and a few months later began seriously experimenting making to date some fifty odd tests.

During the past year the society issued eight mimeographed bulletins and recently a yearbook describing experiments with powder rockets and progress of the society. The present officers are: George James, president; Bob Schubert, vice president; Martin Sherman, secretary and treasurer; and Bert Anderson, chairman of the experimental committee.

With the proven success of jet propelled planes interest has been aroused throughout the country on the possibilities of jet propulsion in the years to come. Many inventors are busy designing their dream jet plane of the future while others with perhaps better means are building and testing jet motors and thermal jet model planes on test stands and small wind tunnels.

Newspapers recently mentioned that Pvt. Charles McIntosh of Dayton, Ohio at the time of his induction into the Army over a year ago, had developed a four foot wingspan thermal jet model plane able to fly for

(Continued on Page 16)

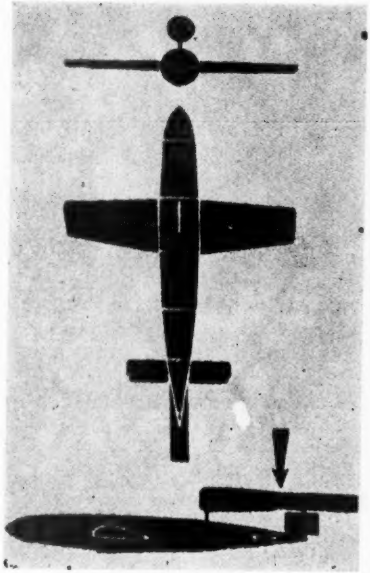
Germany's Robot Bombs

NEW TYPE ROCKET BOMBS IN USE

After being under attack for several years by the British Coastal Air Command, the remaining German rocket launching platforms of the Pas de Calais area recently bombarded the towns of southern England with jet-propelled pilotless bombs. Official description of the Nazis latest secret weapon disclosed that the flying bombs are launched from 200 foot concrete ramps with very likely an auxiliary aid at take-off.

The most common type of robot bomb has a 21 foot 10 inch fuselage, with a maximum width of 2 feet 8¼ inches, and a wingspan of 16 feet. The propulsion unit on the rear of the fuselage makes the over-all length 25 feet and 4½ inches. Having a range of 150 miles, the bombs attain speeds of 350 miles per hour, and carry 2,200 pounds of explosive in the warhead. The engine appears to be a gasoline unit drawing oxygen from the atmosphere and working on the thermal jet propulsion principle. The jet propulsive system mounted over the tail section explodes the oxy-gasoline mixture intermittently, which accounts for the throbbing sound frequently heard. When the engine stops a bright yellow tail light goes out and a few seconds later as the robot loses altitude the charge is exploded.

The rocket bomb is not radio-controlled and once aimed in the general direction of the target and launched all ground control is lost. A gyroscopic mechanical control system holds the bomb as near as possible to its predetermined horizontal course. Entirely constructed of steel the pilotless plane is colored dark green on top and light blue underneath. A number of different types, some carrying a larger charge of explosives, have been destroyed by flak batteries and fighter planes.



—Associated Press

ROBOT BOMB—Front, top, and side view drawings. Arrow points to intermittent jet motor.

Thrust Augmentors For Rockets

Greater Efficiency Through Air Ejector Tubes

by Cedric Giles

Auxiliary air inducing nozzle devices for increasing the velocity and range of the rocket without increasing to an excessive degree the mechanics involved may prove the determining factor in establishing the rocket as an essential atmospheric vehicle. Not only may thrust augmentation be applied to meteorological rockets, rocket gun missiles and atmospheric transportation rockets, but such application also appears feasible for jet propelled airplanes. Thrust augmentors for rockets seem destined as auxiliary boosters when the velocity of the vehicle in relation to the jet is low and due to necessary reliance on atmospheric pressures only at subsonic speeds. The method of supplementing the efflux with a quantity of air is only possible while in the atmosphere; above atmospheric limits any such arrangement of augmentation is naturally useless.

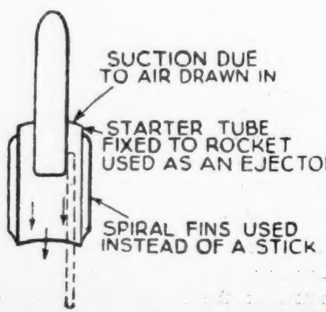
In true jet augmentation all energy imparted to the inflow of the surrounding fluid is a derivative of the energy of the jet which otherwise would be wasted. Obstructions in the gas stream leaving the nozzle will not effect the reactive force of the jet unless very near the nozzle. This permits the addition of nozzle appendages, not blocking the nozzle orifice, for augmenting the original thrust. Impeding the jet flow by nozzle devices resulting in increased combustion chamber pressure can not be considered true augmentation.

Types of Augmentation

The form of thrust augmentation which concerns only external nozzle appurtenances so arranged as to effect the products of combustion after they leave the nozzle aperture may be divided into two general classes each or both, separately or combined, may be employed for boosting the external propulsion efficiency.

1. A starter or launcher tube encases the greater part of the rocket and provides a supplementary impulse at the moment of launching.

2. The combustion gases pass through a series of coaxial air guide ejectors surrounding the jet which induce an extra air efflux mass to supply resultant thrust during flight.



—Flight

The technical development of air scooped up by forward facing orifices or the boundary layer of air sucked in by ducts and delivered to the combustion or by-passed to the nozzle for furnishing additional thrust is not considered in this paper.

Launching Devices.

Up to the time of World War II rocket launching devices in most instances consisted of open troughs, two or more guiding rails or ladder-like framework, or a small carriage which conveyed the rocket to the end of the launching rack. For stabilizing and long range purposes these rockets were endowed with numerous projections such as balancing sticks, wings and fins; decisive items when designing launching devices. Warfare rockets streamlined and rotated by fins or by gases expelled tangentially were launched in most cases from a light weight mortar with the barrel closed at one end.

Although experimented with by an amateur group in the British Isles for a number of years the open ended launching tube did not come into prominence until used in the present war. The tube is now being employed by the United States in the Bazooka and its larger component mounted on personnel Duck boats, by Germany in the Nebelwerfer, Russia in the Katusha, and was originally used in early aerial rocket guns. In this relation an interesting item would be the publication of recoil tests of a Bazooka launching a rocket when using various launcher tube lengths as well as starting the rocket from an open rack. As a protective measure to personnel and nearby equipment the starter tube is most essential in that initial gas flow is confined to the tube and a smaller than otherwise outside area.

One of the few discourses concerning the actual use of the launching tube was recently described by Smith and Dennis in a summary of their research activities in Scotland from 1936 to 1939. The two investigators in one experiment used a commercial-type powder rocket 6 inches long and 1½ inches in diameter which was stood upright on its single 24 inch guiding stick, and a slow burning fusee lighted. A starter tube which consisted of a 20 foot tin pipe of 2¼ inch inside diameter was set over the rocket and rested on the ground. Using the loose fitting tube the rocket was found to travel nearly twice the original distance.

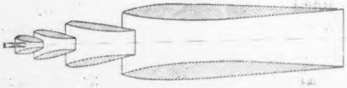
As this experiment suggested the possibility of the rocket gaining an extra thrust due to the exhaust gases pushing against the ground and air and gas confined in the tube a second experiment was made. The same rocket was placed in the tube which was raised slightly above the ground. The tube was noted to jerk forward before the rocket had left it and immediately afterwards. It seems likely that the compression of air and escaping gases in the tube caused it to cling momentarily to the rocket. Once cleared of the rocket the tube probably received an additional noticeable upward thrust from the expulsion of the compressed gases in the tube. Although some resistance from air pressure in the tube

seems certain the rocket largely duplicated its former flight performance. A greater success was noted when the starter tube attached to the rocket acted in flight as an ejector tube. In this experiment spiral fins fixed to the tube substituted for the usual guiding stick.

Ejector Tubes.

In accordance with the theory of thrust augmentation the combustion gases on leaving the chamber-nozzle unit flow through the first ejector stage at a relatively high velocity and a lower pressure at the front opening of the augmentor than the surrounding atmosphere. Due to the higher atmospheric pressure, air is forced into the ejector in the direction of flow adding mass to the jet and receiving a portion of its kinetic energy. The pressure difference acting upon the inner surfaces of the ejector tube exerts a reactive thrust that is transmitted to the entire assembly. The same operation takes place in the second and other ejector stages until such time as the flow has reached the same pressure as the atmosphere.

The efficiency of thrust augmentors is influenced in a large degree before the sonic velocity is approached as a slight change in speed may materially effect the inflow pressure and quantity available. At rest the immediate surrounding medium is aspirated into the device, while in flight fluid is drawn from the air stream. Under the impetus of increasing flight velocities the boundary layer separates from the skin of the vehicle, the laminar flow breaks down into a turbulent wake, and finally a vacuum is formed behind the moving body. Before this stage is reached increased drag of the thrust augmentors will offset the increase in air mass. If deemed profitable the ejectors at the proper moment may be so arranged that they can be dropped for further usage.



Multiple-stage ejector tubes for increasing the jet mass.

The usual increase in burning area in powder charges generates greater gas volume which results in varying the thrust causing a change in the efficiency of the ejector tubes. For best results the air inlets in the ejector stages should be adjustable. Otherwise due to variations of the reactive force of powder charges and the changes in velocities of the vehicle air ejectors will reach maximum efficiency at only one specific point in the speed range.

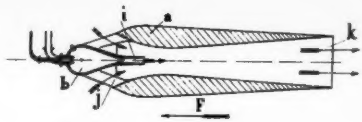
A possible source of additional power is in arrangements whereby the concentric tubes are rotated at predetermined speeds as the effect of centrifugal action on the jet is to increase the momentum of the swirling gases. With proper design and mounting, the stability of a vehicle is also very likely to be benefited at slower velocities by using thrust augmentors.

Multiple-Nozzle Thrust Augmentors.

Numerous investigators during the past three decades have advocated the use of actuated air influx of the jet acting against coaxial cones or tubes for boosting the thrust of rockets or jet driven aircraft. The introduction of graduated overlapping tubes externally attached to jet nozzles particularly for propelling air vehicles are generally attributed to the devices of Melot although a number of inventors preceded him. In the early part of 1909 the American inventor Lake obtained U. S. patent No. 918,336 in which the fluid jet projecting through passages draws air in the direction of flow through slots, the air being heated and expanded, and in turn, augments and slows the jet increasing the mass discharge.

Harris in his 1917 British Patent Specification No. 118,123 proposed long divergent-convergent open end discharge tubes placed over nozzles for increasing the jet mass. The suction created by the nozzle gases traveling through the tube induces air to enter the divergent forward end of the tube. Owing to the cooling effect of the discharge tube the gases are ejected at increasing mass and little change in velocity.

The ejector scheme of Morize, as described in U. S. patent No. 1,375,601 discharges the combustion products from one or more nozzles into a tube first convergent then divergent. A low pressure area is set up by the issuing gases in the convergent end of the ejector which aspirates air through forward inlets. The gases



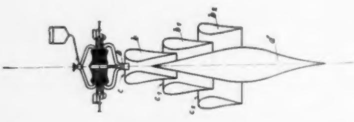
A Single Stage Augmentor Patented by Morize.

are exhausted from the divergent end into the open air at low velocity and increased pressure. A series of progressively larger ejector stages preceding a comparatively large ejector tube is also referred to.

The numerous tests made by M. Henry F. Melot during the last war at the French Laboratoire du Conservatoire des Arts et Matiers were based on the possibility of utilizing trumpet-shaped thrust augmentors for aircraft. The apparatus consisted of a boiler (heated by the "Autoprogressive Burner Melot" for which a number of prizes were awarded) which forced atmospheric air compressed to 300 lbs. per sq. in. into the refractory lined combustion chamber where it burned with an oil (generally naphtha). Gases leaving the nozzle at speeds of 5000 ft. per sec. induced a large quantity of air in the several stage "propulseur de trompe." Thrusts up to 100 lbs. or 30 h.p. were developed in the motor.

In 1920, Melot applied for French Patent No. 523,427 relating to a thrust augmentor device having the gases upon leaving the combustion chamber enter a series of annular guides of increasing size and a main convergent-divergent diffuser tube.

Air inducted at the sides of the nozzles by a low pressure created by the propulsive jet supplements the gas stream.



A Melot patent showing the space adjusting needle.

A later U. S. patent No. 1,493,157, granted in 1924, describes a series of overlapping coaxial ejector tubes with the inner extremity of each tube opening into the neck of the next tube. The first tubes having a greater length than the following cnes, and the addition of a movable needle placed inside the tubes for providing proper passage areas.

N.A.C.A. Ejector Tests.

A series of tests to determine the thrust increase of a jet using Melot type augmentors were made by Jacobs and Shoemaker during 1927 at Langley Field, Va., the results being published in a N.A.C.A. pamphlet five years later.

The test apparatus consisted of a small pressure chamber, supplied by compressed air at normal temperature, and equipped with a pressure gauge and a converging-diverging nozzle of ⅜ in. throat diameter shaped to expand air from 185 lbs. per sq. in. gauge to atmospheric pressure. The thrust weighing balance, on which the chamber was mounted, measured the thrust of a free jet for comparison with thrust from various combinations of the three small spun-copper vanes and a large 3 ft. 9 in. in length Venturi* tube.

Readings at chamber pressures ranging from 25 to 200 lbs. per sq. in., at velocities up to 1,700 ft. per sec., showed that below 100 lbs. pressure the free jet had a poor efficiency while at 185 lbs. reached 90 per cent of the theoretical thrust. A small increase in thrust was noted with the small augmentors, a larger increase with the Venturi tube (mostly from the divergent section) at 100 lbs. pressure at spacing of 6 inches from the chamber, with the Melot type of augmentation giving a maximum thrust of nearly 1.4 times the theoretical free jet reaction at 90 lbs. per sq. in. gauge pressure.

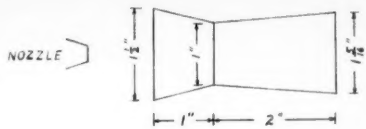
An investigation on the feasibility of thrust augmented jets as prime movers was conducted at the Bureau of Standards with the assistance of the N.A.C.A. by G. B. Schubauer in 1930. Small size nozzles and augmenting devices, including airship mcdels with radial nozzles in nose and tail, were static tested experimentally in the Bureau's 3 foot wind tunnel.

Air supplied by a compressor (not in the tunnel) to a small one quarter inch throat diameter nozzle was ejected at speeds up to 1,240 ft. per sec. All measurements were recorded

---

*Venturi meter, after Giovanni B. Venturi (1746-1822) Italian physicist.

by a pendulum-type balance with the majority of the augmented annular nozzles and Venturis showing little or no improvement over the free jet used as the basis of comparison. A slightly modified Melot angular throat Venturi at the maximum 1,240 ft. per sec. jet speed yielded an augmentation of 10 per cent.



An N.A.C.A. Venturi which gave a 10 per cent augmentation.

The possibilities of an intermittent jet with thrust augmentors—reported with fair results by Melot—and a transverse jet moved from place to place with intermittent emission was discussed briefly with the outlook not too favorable. Special tests on the effect on augmentation by a wind such as the air pressure the forward motion of a vehicle would create, showed no increase in efficiency.

Research In Scotland.

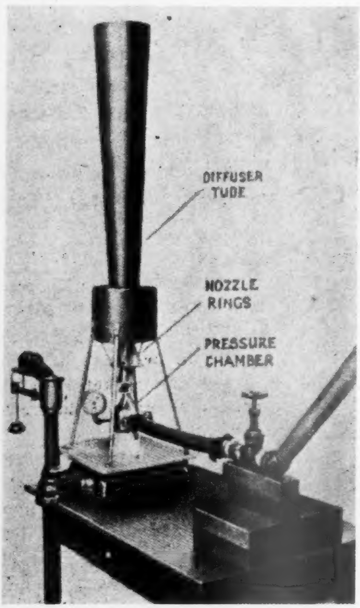
The most startling results obtained with ejector tubes were achieved shortly before the present war by experimenters in Scotland. An early powder model with a wing span of 4 feet flew a distance of nearly 3 miles in one minute at Loch Lomond in 1920. The 180 m.p.h. flying model had a steel cased motor and a four inch diameter cardboard tube surrounding the jet which aided the thrust considerably. Later models, based on the original, covered distances greater than 5 miles.

Tests on small rockets employing thrust augmentor units rotated on a centrifugal teststand showed the great advantages of gas ejectors. The powder fueled captive rocket fixed to a central boss traveled over a circular concrete path some 20 yards in diameter. The operation consisted of firing the rocket at low speed from a launching tube (which was immediately removed) and using a three stage cardboard thrust augmentor. At a velocity of 350 ft. per sec. air pressure blew the third ejector off, and at 800 and 1,800 ft. per sec. respectively, the remaining two stages dropped off as the rocket continued to accelerate. Velocities up to 3,000 ft. per sec. (2,000 m.p.h.) were measured by stroboscopes or computed by examination of photographic films.

A combination starter - ejector simple steel or cardboard tube of 2 in. diameter and 4 in. long fastened to a 1½ in. diameter rocket was found to triple the rocket speed at low velocities. A marked difference in efficiency was noted in cases of rockets with 1/12 in. diam. jet nozzles effusing 40 grains of powder per second for a thrust of 1 lb. when upon using ejectors an average of 6 lbs., with a maximum of 10 lbs. was attained. Large size ejectors used on a jet expelling ¼ oz. of powder per sec. for a 3 to 4 lb. thrust gave a 150 lb. force at 50 m.p.h. and reduced the 50 h.p. in the efflux to 20 h.p. at 7,000 ft. per sec.

In one instance a Tiger Moth was assisted into the air by an ejector device weighing 33 lbs. and measuring 22 in. in diam. and 11 ft. in length. The one lb. of powder composition gave 150 lbs. thrust up to 50 m.p.h. but dropped to 100 lbs. at 100 m.p.h. A final experiment consisted of an ejector unit 20 ft. in diam., 40 ft. long, and weighing two tons. Combined with a jet having a gas flow of 2 lbs. per sec. at 7,000 ft. per sec. with a 6,500 h.p., a six ton thrust was attained on speeds below 80 m.p.h.

Gas retainers, external sections surrounding the rocket body proper



—Flight

The test apparatus used in N.A.C.A. augmentor experiments.

for channeling head air to supplement the jet, also gave fair results. Using the gas retainers on rockets launched from starter tubes invariably saw the retainers blown off as the rocket entered the outside atmosphere.

Direpeller System.

To improve the external propulsion efficiency Ernest Lagelbauer of New York City has suggested a "Direpeller" system which reduces the velocity of the jet to more nearly the velocity of the vehicle, and augments air to the combustion gases. The air stream passing through the direpeller tube is directed in a transverse plane partially by deflector vanes and greatly by the direct impact of the combustion gases entering the tube at right angles. The slowed combustion gases now greatly augmented pass through a momentum equalizer and the rectifying blading where the angular momentum is converted into thrust.

ASTRONAUTICS has printed numerous ideas, schemes, and experiments by members of the Society dealing with thrust augmentor devices. Experimental Rocket No. 3, designed in 1933 by B. Smith and G. Edward Pendray contained in the lower part a Venturi-shaped section into which the combustion gases discharged. The thrust augmentor was expected to increase the jet thrust as much as 10 to 15%, and add stability during flight, but due to construction difficulties and additional weight the idea was abandoned.

After a series of combustion chamber tests, H. Bull reported in

1932 the increase in power and longer firing time of chambers having Venturi-shaped cones 15 inches in length and 3 inches in diameter placed slightly in front of the nozzle. In tests of two identical chambers each using the same amount of fuel and giving the same average reaction, the Venturi employed chamber ran 110 seconds to the 56 seconds of the other.

A paper by W. T. Heyer in 1940 described a test apparatus having acetylene gas fed through a glass tube with one end forming a nozzle which was fastened to a Venturi tube suspended in the airstream of a blower. Any movement of the Venturi tube due to the burning gas was recorded on an indicator. None of the five different Venturi sections tested showed a positive tractive force. At last reports a second series of experiments were being considered.

Consulted References.

Jacobs, Eastman H., and Shoemaker, James M.: Tests on Thrust Augmentors for Jet Propulsion. T. N. No. 431, N.A.C.A., 1932.

Schubauer, G. B.: Jet Propulsion with Special Reference to Thrust Augmentors. T. N. No. 442, N.A.C.A., 1933.

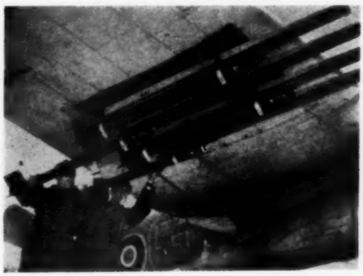
Smith, J. J., and Dennis, J.: Rocket Research. Flight, Dec. 2, 1943.

Lagelbauer, E.: Method of Aircraft Propulsion. Mechanical Engineering, Jan. 1944.

ASTRONAUTICS, Nos. 21, 27, 46, 47, and 52.

PLANE ROCKETS

Recent disclosures by the Army and Navy have revealed that rocket-firing planes are in use in the China-Burma-India and Pacific war theatres. Attacks have been reported against land and sea targets by planes mounting one to four rockets under each wing. The U. S. planes mentioned carrying this new weapon are B-25 Mitchell, P-38 Lightning, P-39 Airacobra, P-40 Warhawk, P-47 Thunderbolt, P-51 Mustang, TBF Avenger and F4U Corsair.



Placing Rockets on Guide Rails of the Bristol Beaufighter.

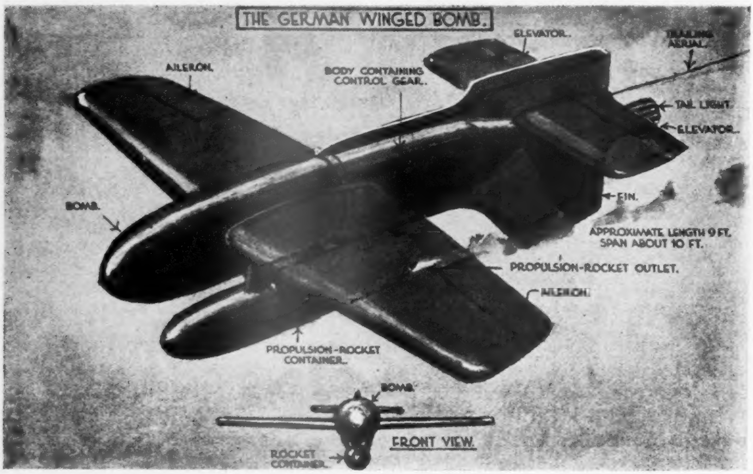
British planes also are using rocket projectiles fired from beneath their wings at targets on land and sea. The weapon, officially called R.P., consists of four rockets hung on rails under each wing. The firing procedure, after sighting the target with the rails, is to discharge the rockets in pairs, one from each wing, or all eight together in one salvo. The rocket is made up of a shell tube with an explosive head, with a propelling charge of cordite ignited by the pilot by a platinum fusee wire. During flight the rocket is stabilized by four fins attached to the tail.

RADIO-CONTROLLED ROCKET BOMB

Additional details of the German crewless radio-controlled rocket glider bomb launched from airplanes are reported by eye-witnesses stationed on convoys against which the weapon was employed. A number of versions of the winged bomb appear in use, the most common one being shown in the accompanying drawing. Assembled in two sections, the winged bomb carries the rocket container in a separate case slung directly under the bomb fuselage with the propulsive jet ejecting rearward and slightly downward. The rear part of the body contains electrical equipment for controlling the bomb in flight. A trailing aerial picks up the radio impulses and a bright tail light assists the controller in the parent plane to direct its flight at some 300-400 miles per hour. The parent-controlling aircraft takes up a position about four miles from the target and flies in the same direction at 2000 to 4000 foot altitude during the attack.

Glendale Rocket Society Year Book, 1943-1944; 45 pages.

The first annual yearbook of the one year old Glendale Rocket Society details the year's progress in rocket experimentation and other accomplishments of the society. A three page article on rocket weapons in the present war, numerous short items by members, excerpts from ASTRONAUTICS, and comments on the future aims of the society complete the book.



As the Illustrated London News visualizes the radio directed Rocket Bomb reported by an eye-witness.

The Rocketor's Primer

TEST STAND FUNDAMENTAL FORMULAS

The characteristics of a rocket motor are expressed by certain word terms, many of which are common to both the powder and the liquid fueled motors. Following is given a list of oft-used symbols applying to the liquid fueled motor with their definitions.

R = Reactive thrust of motor forward, lbs.

t = Time of combustion, secs.

f = Flow rate of gases ejected or liquids injected, lbs. per sec.

v = Velocity rate of gases ejected, ft. per sec.

K. E. = Kinetic fuel energy output of the jet, ft. lbs. per sec.

H = Heat energy input of the fuel, ft. lbs. per sec.

E = The efficiency ratio of effect produced to the energy expended, percentage.

On some rocket test stands, gages indicate the jet reaction, the chamber pressure, the weights and pressures of the fuel and oxidizer, and a large split-second clock the duration of firing in seconds. During a test run a photographic record is made of the various dial readings. After the film is developed the film frames are examined second by second and graphs are plotted. From the data obtained the efficiency of the tested motor is determined.

In the following example of a hypothetical motor, the factors needed, formulas, and the usual accepted method of calculating the efficiency is shown.

Average jet reaction—32 lbs. per sec.

Time of combustion—10 secs.

Fuel - alcohol—1 pint (.825 lbs.—Sp. Gr. .79).

Liquid oxygen—2 pints (2.38 lbs.—Sp. Gr. 1.14).

B.T.U. for alcohol—12000 B.T.U. per lb.

1 B.T.U. = 778 ft. lbs.

g = gravity (32 lbs.)

W = weight of propellants

w = lbs. of alcohol.

Average jet flow $\frac{W}{t}$

$$\frac{3.2}{10} = .32 \text{ lbs. per sec.}$$

Average jet velocity $\frac{R \times g}{f}$

$$\frac{32 \times 32}{.32} = 3200 \text{ ft. per sec.}$$

Average fuel output

$$\frac{f \times (v)^2}{2 \times g} \text{ or } \frac{R \times v}{2}$$

$$\frac{.32 \times (3200)^2}{2 \times 32} \text{ or } \frac{32 \times 3200}{2} = 51200 \text{ ft. lbs. per sec.}$$

Average fuel input $\frac{w \times \text{B.T.U.} \times 778}{t}$

$$\frac{.825 \times 12000 \times 778}{10} = 770220 \text{ ft. lbs. per sec.}$$

Thermal efficiency $\frac{\text{K.E.}}{\text{H}}$

$$\frac{51200}{770220} = 6\tfrac{1}{2}\%$$

AMERICAN ROCKET PIONEERS

Patrick Cunningham

A sailor and an inventor was Patrick Cunningham, who combined his love for the sea with an interest in rocket propulsion to produce the famous life-saving rocket gun, a harpoon which won a gold medal from the Smithsonian Institute, a torpedo, and many other devices which have helped the sailors master the sea. Patrick Cunningham—born in Dundolk, County Lough, Ireland, just one hundred years ago — came to this country when a young boy. The Civil War broke out when "Pat" was seventeen and he enlisted in Sickles' Brigade and served until officers discovered the tenderness of his age. At twenty he was finally able to enlist in the United States Navy where he learned enough about explosives and projectiles to develop a life-long interest in their application.

After the war "Pat" sailed on an adventurous whaling voyage to the Arctic on the "Rainbow" on which he made one of his first inventions—a bomb lance fired from a breech loading gun and also designed the gun. Back at New Bedford, Mass., Cunningham produced his famous life-saving rocket which carried its own slow-burning powder and its own line to the distressed ship at sea.

The American Carrier Rocket Company, his backers, sent him abroad to pick up improvements. Not being welcome at arsenals in England and Germany, he was forced to employ subterfuge and disguised as a draftsman of James Payne, the well-known American fireworks manufacturer, managed to get into the Woolwich Arsenal, England four times.

Sometime in the beginning of the 90's Cunningham decided to sell all his rocket interests to his backers and thereafter devoted all his energies to torpedo development. His efforts ended in dismal failure, but however. he had the belated satisfaction, like so many inventors, of seeing most of his predictions about the torpedo work out in World War I.

Patrick Cunningham died in New Bedford in May 1921 after enriching the world with 22 patents, among them being rocket patents numbers 266,437; 395,881; 455,278; 455,279; and 479,738.

Jean Mater

At Camp Davis, N.C., rockets are fired from specially designed two-wheeled launching carriages for training anti-aircraft gunners to cope with enemy dive bombers. The ack-ack men are equipped with .50 calibre machine guns and 20 and 40 mm. weapons for knocking down the speedy jet propelled projectiles. Each rocket is composed of a 59 inch tube containing the powder propelling charge and has three large size stabilizing fins. Traveling at velocities of 450 miles per hour (675 ft. per sec.) the rockets reach maximum horizontal ranges of 2,200 yards.

BOOK REVIEWS

Rockets: The Future of Travel Beyond the Stratosphere, by Willy Ley. The Viking Press, New York, 1944; 287 pages, $3.50.

Astronomy through the ages, early literature and ideas on flying and interplanetary travel are convincingly described. The development of foreign experiments and the accomplishments of the German Rocket Society (of which the author was the secretary) are covered up to 1935. Throughout the latter chapters mass-ratio concepts are theoretically considered in dealing with meteorological and space rockets. Illustrated by photographs and drawings the book is completed with a large number of notes, a bibliography and an index.

Papers On Rocketry, Publication No. 3, M.I.T. Rocket Research Society. Cambridge, Mass., 1944; $1.00.

This material was collected by members of the Society principally as a guiding literature for experiments by the Society. References and tables are included in the papers.

Subsonic and supersonic flow in rocket design, by Edward Doyle.

Methods of control for rocket propelled aircraft, by Robert Fauvre.

Energy relations in rocket propulsion, by Professor M. Rauscher. Supplementary notes by John Fisher.

Rocket propellants, by John H. Pomeroy.

Methods of high temperature measurement, by Robert B. Smith.

Refractories for rocket motors, by Robert B. Smith.

Jet Propulsion, by Thomas N. Dalton. Elizabeth, N. J., 1944; 45 pages, $1.00.

This pamphlet attempts to show how vague is the plan on using jet propulsion for airplanes as the laws of Newton and Carnot portend that jet driven planes will be extremely impractical. The sections mathematically consider the principles of jet propulsion, thermodynamics, effectiveness of propulsive forces, and the basic difficulties of gas turbine machines.

A recently issued supplement entitled "J-P Fundamentals" mathematically describes the various factors in relation to rocket type propulsion and turbine-compressor jet propulsion. The 11 page supplement is priced at 50 cents.

A USE OF THE BAZOOKA.

Major R. W. Schmelz, FA in the **Field Artillery Journal** (Nov. 1943) suggests a distribution of bazookas to the firing battery and discusses the tactical employment of the rocket launchers in a number of situations.

As a defense weapon against tank attack three general periods are considered: in rendezvous (or bivouac), on the march, and in position. Each of these periods is taken up separately and the assigning of rocket launchers to the various areas for maximum effectiveness is thoroughly outlined. Schematic diagrams illustrate the most essential locations for placing the launchers in different terrain and the procedure for vehicle defense.

NOTES AND NEWS

(Continued from Page 2)

15 minute periods. Chemicals induced into a small mixing chamber produce acetylene gas which is injected together with a large supply of air into the combustion chamber. The gases on being ignited by an electric spark are ejected through nozzles to provide forward thrust to the craft.

Future Jet-Propelled Wing.

From Washington, D.C., comes word that Eric Langlands has invented a working model flying wing which performed most successfully in wind tunnel tests. This possible airliner of the future is driven by jet propulsion and has a helium filled upper section allowing the craft to hover at will. Air drawn in through forward intakes is compressed by heating and exhausted via rear vents.

CONTENTS

Cover: British "Z-Guns".

Notes and News: Reports from experimenters and inventors .... Page 2

Germany's Robot Bombs: A new type now in use .... Page 3

Thrust Augmentors For Rockets: Air ejector tubes described ..... Page 4

Plane Rockets: U. S. and England using rocket projectiles .... Page 11

Radio-Controlled Rocket Bomb: More information on the winged bomb.. Page 12

The Rocketor's Primer: Test stand fundamental formulas .... Page 13

American Rocket Pioneers: Patrick Cunningham .... Page 14

Book Reviews .... Page 15

Statements and opinions expressed by contributors in ASTRONAUTICS do not necessarily reflect the views of the American Rocket Society.

ASTRONAUTICS, official publication of the American Rocket Society, is devoted to the scientific and engineering development of the rocket and its application to problems of research and technology. Published by the American Rocket Society, 130 W. 42nd St., New York City. Subscriptions with Associate Membership, $3 per year. **Copyright, 1944, by the American Rocket Society, Inc.** **Editor: Roy Healy.**